(See Instructions on reverse of form)

Form AD 421 (4/77) U.S. DEPARTMENT OF AGRICULTURE

RESEARCH WORK UNIT/PROJECT DESCRIPTION - PROGRESS REPORT

U.S. DEPT. OF AGRICULTURE, STATE AGRICULTURAL EXPERIMENT STATIONS AND OTHER INSTITUTIONS

DATE (Day, Mo., Yr.): 06 MAR 86

1. ACCESSION NO.	AGENCY IDENTIFICATION NO. 2.	3.	4.	5. WORK UNIT/PROJECT NO.	6. STATUS TERMINATED	30. ESTIMATED TERMINATION DATE
0049691	ARS	1203	30 00	1203-20254-002-01T	E [X]	31 DEC 85

7. TITLE

DEVELOPMENT OF SUITABLE INSECTICIDES AND TECHNIQUES FOR AIRCRAFT DISINSECTION

8. PERFORMING ORGANIZATION

ARS, Livestock Insects Laboratory
Agricultural Environmental Quality Institute
Rm. 120, bldg. 307, BARC-East

12. INVESTIGATOR NAME(S)

1 Hayes, D. K.
2 Morgan, N. O.
3
4
5
6

84. PERIOD COVERED BY THIS REPORT (Month & year)

From: 01 JAN 82 To: 31 DEC 85

35. PROGRESS REPORT

During 1982, five new compounds, S-2703, S-3206, S-2852, S-4068 and FCR 1272 were formulated as 30% dust and 2% aerosol and were tested in large scale field tests in Miami and Baltimore in trailer vans. During 1983, cypermethrin, S-3206, S-4068 and FMC 54800 were effective toxicants for D. variabilis, Popillia japonica, Blattella germanica and Anopheles quadrimaculatus in tests in Miami and Baltimore. Musca vitripennis, introduced on two occasions in 1982 in N.J., was not found in 1983 in extensive trapping. During 1984 six insecticides were identified as effective for controlling ticks, flies, cockroaches and Japanese beetles in aircraft disinsection trials. During 1985, aircraft disinsection trials conducted to develop new chemicals for use in aircraft were completed. Based on Log-probit analyses of the data, bendiocarb dust was highly effective against Blattella germanica as was methomyl dust against Popillia japonica and S-2703f aerosol against Dermacentor variabilis. Glossinia morsitans morsitans, Anopheles quadrimaculatus and NAIDM Musca domestica were susceptible to all materials tested against them.

37. PUBLICATIONS

HAYES,D.K. 1984. The history and present status of aircraft disinsection. In: Commerce and the Spread of Pests and Disease Vectors, Praeger Pubs, New York. Proc. XV Pacific Science Congress, Symp 7, New Zealand, Feb. 83, pp 23-36.

MORGAN,N.O., STRASSER,E.G. and WITHERELL,P. 1983. Candidate pesticides for quarantine use, 1982. Insecticide and Acaricide Tests 8, 78.

MORGAN,N.O., CARROLL,J.F., STRASSER,E.G. and KLAG,N.G. 1984. Candidate pesticide formulations for quarantine use, 1982. Insecticide and Acaricide Tests, 9, p 397, #514.

MORGAN,N.O., WITHERELL,P., STRASSER,E.G. and WOOD,W.S. 1984. Candidate pesticide formulations for quarantine use, 1983. Insecticide and Acaricide Tests, 9, p 399, #515.

MORGAN,N.O., SCHMIDTMANN,E.T., FONS,J. and HAYES,D.K. 1985. Aircraft disinsection: An international concern for the protection of man and agriculture. Proc. XVII International Congress of Entomology, Hamburg, Germany, Aug. 84. Vet. Parasitol. 18:235-239.

SCHMIDTMANN,E.T., RUSSEK-COHEN,E., MORGAN,N.O., GERRISH,R.R., WILSON,D.D. and GAGNE,R.J. 1985. Introduction and survey for exotic Musca vitripennis (Diptera:Muscidae) in New Jersey, USA. J. Econ. Entomol. 78:1320-1322.

HAYES,D.K. 1985. Input into "Recommendations on the Disinsection of Aircraft." WHO Weekly Epid. Rec. 7:45-47.

APPROVED (Signature)	TITLE	DATE

AIRCRAFT DISINSECTION AND OTHER RESEARCH OF INTEREST DURING 1985

Report for the

WORLD HEALTH ORGANIZATION*

Livestock Insects Laboratory

Agricultural Environmental Quality Institute

Agricultural Research Service

U.S. Department of Agriculture

Beltsville, Maryland 20705

*Partially supported by Trust Fund Cooperative Agreement No. 58-32U4-3-513 Amendment No. 3, entitled "Research on Aircraft Disinsection"

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UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Service

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Agricultural Environmental Quality Institute
- Chemicals Coordination
- Analytical Chemistry
- Biologically Active Natural Products
- Biological Waste Management & Organic Resources
- Insect Reproduction
- Livestock Insects
- Organic Chemical Synthesis
- Pesticide Degradation
- Soil Nitrogen & Environmental Chemistry
- Weed Science

Animal Parasitology Institute
- Parasite Classification & Distribution
  - National Parasite Collection
  - Index-Catalogue of Medical & Veterinary Zoology
- Nonruminant Parasitic Diseases
- Poultry Parasitic Diseases
- Ruminant Parasitic Diseases

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- Avian Physiology
- Meat Science Research
- Milk Secretion & Mastitis
- Nonruminant Animal Nutrition
- Reproduction
- Ruminant Nutrition

Horticultural Science Institute
- Florist & Nursery Crops
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- Horticultural Crops Quality
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Insect Identification & Beneficial Insect Introduction Institute
- Beneficial Insect Introduction
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- Cell Culture & Nitrogen Fixation
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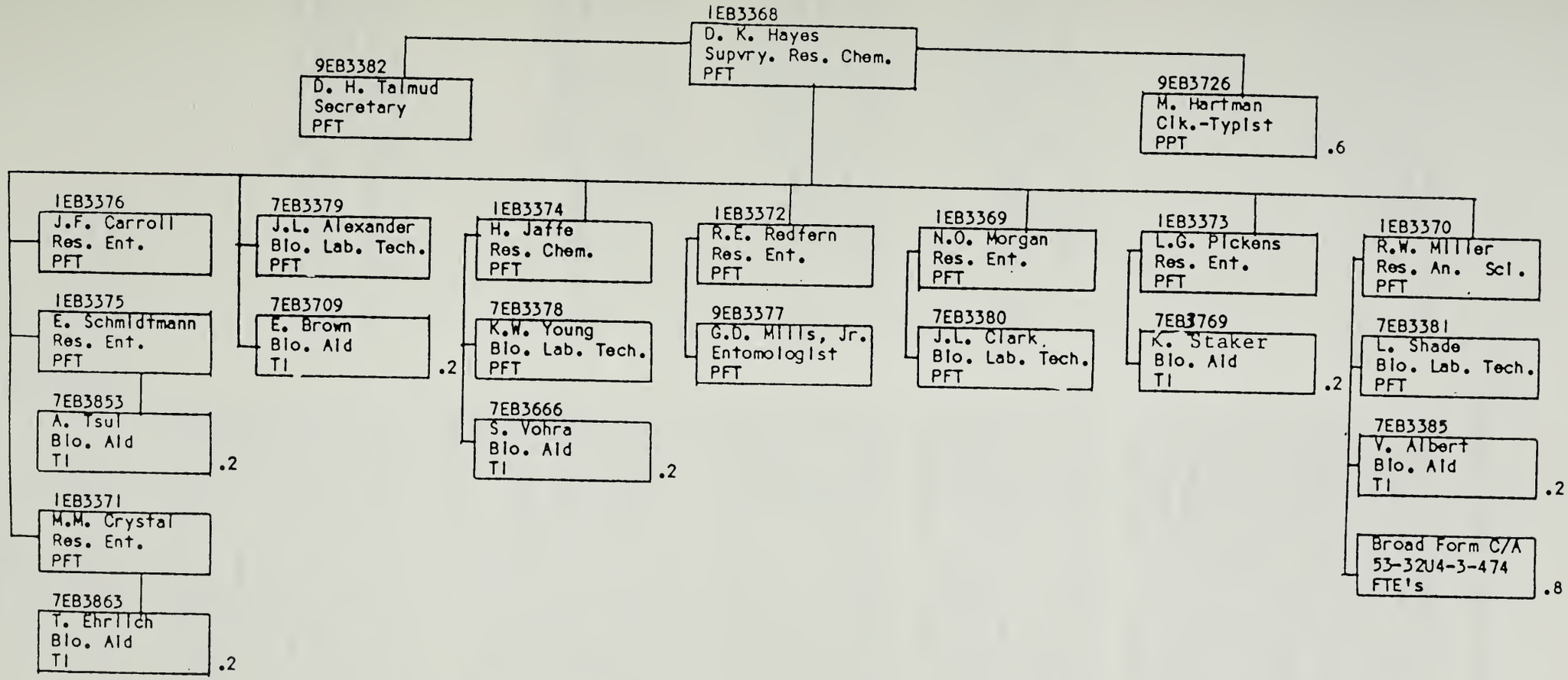
- Plant Hormone
- Plant Stress
- Water Data

Plant Protection Institute
- Applied Plant Pathology
- Bioenvironmental Bee
- Insect Pathology
- Insect Physiology
- Mycology
- Nematology
- Plant Virology
- Soilborne Diseases

Livestock Insects Laboratory
Agricultural Environmental Quality Institute
Beltsville Area
Beltsville, MD
MODE CODE: 03 10 12 1203 30 00 00 00

Position Staffing Plan
Plan 4



SUBMITTED: Dora K. Hayes — Research Leader — Date: 8-30-85

CONCUR: _____ — Institute Director, AEQI — Date: _____

APPROVED: _____ — Director, Beltsville Area — Date: _____

Livestock Insects Laboratory

Dr. Dora K. Hayes, Chief
Research Chemist
Rm. 120, Bldg. 307
Beltsville, Maryland 20705
301-344-2474

Examines biochemical aspects of manipulations of photoperiod and temperature (biological rhythms/chronobiology) on insect development, maturation and life span emphasizing neuropeptides and biogenic amines and their receptors. Evaluates biochemistry of rhythms with varying periodicities. Studies biochemical and behavioral aspects of vision in Diptera. Conducts laboratory and field tests as required to determine feasibility of application of biochemical and biophysical findings to practical insect control techniques.

Dr. John F. Carroll
Research Entomologist
Rm. 201, Bldg. 307
Beltsville, Maryland 20705
301-344-4172

Studies biology and physiology of the American dog tick in the laboratory and applies the findings to the development of improved methods for population management. Develops and verifies population models for the American dog tick and conducts research with compounds designed for fumigation of food products and greenhouses.

Dr. Maxwell M. Crystal
Research Entomologist
Rm. 227, Bldg. 307
Beltsville, Maryland 20705
301-344-2017

Conducts research on the biology and behavior of the northern fowl mite and evaluates toxicants for the control of northern fowl mite populations. Develops in vitro feeding techniques for mites and determines effects of known insect hormones, hormone analogues, neurotransmitters on mite development.

Dr. Howard Jaffe
Research Chemist
Rm. 203, Bldg. 307
Beltsville, Maryland 20705
301-344-4168

Develops systems for use of controlled release technology in which insect growth regulators, ecdysteroids and other hormone-like compounds are used against arthropod pests of livestock. Identifies and isolates invertebrate neuropeptides from tissue by high performance liquid chromatography. Investigates the role of these peptides in insect metabolism and development.

Dr. Richard W. Miller
Research Animal Scientist
Bldg. 177A
Beltsville, Maryland 20705
301-344-2478

Investigates various methods to control face flies on cattle as well as other filth breeding pest flies. These include technologies to kill both adult and immature stages of the fly. Also investigates the use of feed throughs or feed additive technology to control fly pests of poultry. Develops concepts and methodology to initiate an IPM program to control flies on dairy cows and around dairy cattle operations; develops and validates filth fly population models.

Mr. Giles D. Mills
Entomologist
Rm. 10, Bldg. 309
Beltsville, Maryland 20705
301-344-2298

Investigates insect growth regulators and materials that affect insect growth and development

Dr. Neal O. Morgan
Research Entomologist
Rm. 121, Bldg. 307
Beltsville, Maryland 20705
301-344-2277

Plans and executes research to identify insect toxicants, fumigants and attractants/repellants to develop new methods of administering these compounds to insects and the American dog tick, especially those that transmit diseases. Develops procedures and technologies to study effects of neuropeptides and neurotransmitters on the American dog tick, filth flies and other model insects during the circadian cycle and during the life span.

Mr. Lawrence G. Pickens
Research Entomologist
Bldg. 177A
Beltsville, Maryland 20705
301-344-2974

Investigates chemical and physical methods of controlling flies on cattle. Develops attractants and traps, and tests chemicals and materials in both field and laboratory to determine their effectiveness. Participates in pilot test to determine efficacy of sticky, pyramidal traps, attractant and other traps in control of face flies. Investigates ecology and bionomics of flies in the field. Conducts studies on the physiology of vision in Diptera and determines effects of neuropeptides and neurotransmitters on vision at different times of day (biological rhythms) during the adult life span.

Mr. Robert E. Redfern
Research Entomologist
Rm. 10, Bldg. 309
Beltsville, Maryland 20705
301-344-2298

Determines novel effects of insect neuropeptides and develops bioassays for these substances. Conducts research on the activity of synthetic or natural materials which inhibit or prevent insect development or reproduction. Investigates insect growth regulators (juvenile hormone-mimics; anti-juvenile hormone-mimics; chitin inhibitors), and materials affecting insect development and reproduction on the (a) morphological and physiological development of qualitative and quantitative methods for determining the juvenilizing, anti-juvenilizing, anti-reproductive, or chitin inhibitory effects of the compounds tested. Perfects and/or develops bioassays to detect synergism or candidate chemicals to juvenile hormone-mimics. Determines interaction of daily light/dark and temperature rhythms on the diapause response.

Dr. Edward T. Schmidtmann
Research Entomologist
Bldg. 177A
Beltsville, Maryland 20705
301-344-2973

Investigates integrated methods of control of filth flies, especially face flies. Investigates economic aspects of face fly infestation on dairy herds. Conducts research to discover interaction between face fly and other pest behavior and host behavior; examines ecology and population dynamics of pest. Studies ecology of immature filth flies on dairy farms especially in calf pens.

LIVESTOCK INSECTS LABORATORY

Program Mission Statement

To control arthropod pests of livestock, scientists investigate feed additives, fumigants, antifeedants, toxicants, and juvenoids. Basic studies on diapause (dormancy) delve into insect metabolism while applied research improves controlled release formulations and aircraft disinsection (destruction of insect hitchhikers after overseas flights).

LIVESTOCK INSECTS LABORATORY

CRIS Unit Summary - CY 1985

This report summarizes work done on aircraft disinsection and fumigant evaluation during CY 1985. This work was conducted primarily under CRIS unit 1103-20254-002; at present new CRIS units in part approved for program of LIL. Titles of these new CRIS units are provided in this report. A summary of the pertinent objectives and approaches of pertinent parts of the FY 1984 work plan is included followed by drafts of appropriate papers and reports.

LIVESTOCK INSECTS LABORATORY

CRIS Work Unit Relationships
During CY 85

Work Unit No.	Title
1203-20254-005 Jaffe, Hayes, Redfern Morgan, Carroll	Chemistry and biochemistry of peptide neurohormones
1203-20254-006 Pickens, Carroll, Morgan	Electrophysiology of vision in fly and tick pests of livestock
1203-20254-007 Crystal	Northern fowl mite behavior, physiology, biology and control.
1203-20254-008 Morgan, Hayes, Redfern	Biochemistry of fce fly receptors for adipokinetic and diuretic neuropeptides and for biogenic amines
1203-20254-009 Redfern, Morgan, Mills	Novel bioassays for evaluation of candidate insect peptides, growth regulators and controlled substances.
1203-20254-011 Morgan, Carroll	American Dog Tick Behavior, Physiology, Survival and Control
1203-20480-007 Hayes, Miller, Pickens Schmidtmann, Redfern	IPM component research for management of dairy fly and poultry insect populations.
1203-20480-008 Schmidtmann, Pickens	Biology, control and economic impact of house flies, stable flies and face flies in the dairy environment.

LIVESTOCK INSECTS LABORATORY
Annual Research Progress - CY 1985

CRIS Work Unit: - 1203-20254-002

Aircraft Disinsection

Work is summarized in the attached papers by N. O. Morgan. Six insecticides were identified as effective for controlling ticks, flies, cockroaches and Japanese beetles in aircraft disinsection trials.

During FY 85 D. K. Hayes attended the World Health Organization Consultation on Aircraft Disinsection held in Geneva, Switzerland, November 18-24, 1984. A summary of the results of the meeting and of the recommendations is attached.

Fumigation Studies

Fumigation studies are summarized in the paper and manuscript by Weber et al.

LIVESTOCK INSECTS LABORATORY
Annual Research Plans - 1986

Aircraft Disinsection:

Work on aerosols as space sprays for aircraft disinsection has been discontinued. LIL will continue to develop methodologies for application of materials to surfaces as a means for managing pest insect populations.

LIVESTOCK INSECTS LABORATORY
Annual Research Plans - 1987

Determine how to treat surfaces, especially of pyramids and octagons, to permit utilization of a single application of a pesticide over a time span of up to 6 weeks.

Concentrate on the purification of sufficient materials for sequencing and synthesis of the PANH peptides for structural confirmation and biological studies. Work will continue on isolation, purification and structural determination of the PANHs of Heliothis virescens.

Determine the full range of biological activities of the AKH family and synthesize agonists and antagonists.

Evaluate our various CR systems in laboratory animals and finally in cattle (ARS, Kerrville, Tx.) against ticks. In addition, we hope to inject the microcapsules directly into insects and ticks as a novel method to study the effects of prolonged delivery of hormone analogues.

Continue pilot test project. This will include work on biological, chemical, and cultural control techniques, monitoring procedures, and development of population models and on use of pyramidal traps.

Develop cooperative research projects with foreign scientists on poultry feed-through compounds (PL 480 project with Yugoslavia) and biology and control of Musca vitripennis flies (OICD project with Portugal).

Suggest improvements and modifications for subsequent aircraft disinsection by another agency.

Improve methods and means for killing ticks affecting man and animals.

Determine the feasibility of non-insecticidal materials for controlling ticks affecting man and animals.

Determine other potential methods for controlling ticks; i.e., fumigants, attractants, repellent, mechanical barriers, physiological barriers, etc.

Continue to conduct series of experiments to define face fly, stable fly and house fly vision in colorimetric terms.

Attempt to determine the visual sensitivity curves of the American dog tick and of various tabanid flies (horse flies).

Continue research into methods of bioassaying compounds which affect insect vision.

Develop new or novel bioassays for evaluation of controlled substances such as marijuana, coca, cacti and derivatives.

Develop techniques for evaluation of microencapsulated insect steroids and insect juvenile hormone mimics.

Continue to conduct series of experiments to define face fly, stable fly and house fly vision in colorimetric terms.

Attempt to determine the visual sensitivity curves of the American dog tick and of various tabanid flies (horse flies).

Continue research into methods of bioassaying compounds which affect insect vision.

Investigate fly activity as stress in the context of effect on herd/cow social structure, lactation/physiology and behavioral modulation.

Investigate 1) how the bacterial flora of calf pens influence house fly and stable fly maggot growth; 2) how calf pens can be managed to adversely affect pest species, emphasizing moisture reduction; 3) competitive interactions between house fly and stable fly maggots and other biota.

As required, conduct evaluation of candidate fumigants.

LIVESTOCK INSECTS LABORATORY

Technology Transfer

Livestock Insects Laboratory (LIL) will continue to work on developing residuals on surfaces to control pest insects, and on other areas related to interests of WHO.

Since LIL performs research in support of the Animal and Plant Health Inspection Service (APHIS), technology transfers involving regulatory aspects proceeds in a manner consistent with USDA policy, and LIL will continue to furnish support to this Agency. As key discoveries are made involving both disinsection and disinfection they will be transmitted to APHIS.

LIL will facilitate, as appropriate, WHO contacts with Armed Forces Pest Management Board, Department of Defense, of the United States.

LIVESTOCK INSECTS LABORATORY
Publications List - 1985

Carroll, J. F. Caribbean fruit flies, Anestrepha suspensa (Loew) (Diptera: Tephritidae reared from eggs to adults on cannibalistic diet. Proc. Entomol. Soc. Washington. Accepted.

Carroll, J. F. and Grasella, J. J. Occurrence of adult American dog ticks, Dermacentor variabilis (Say), around small mammal traps and vertebrate carcasses. Proc. Entomol. Soc. Washington. Accepted.

Carroll, J. F. and Nichols, J. D. Parasitization of meadow voles, Microtus pennsylvanicus (Ord), by Ameridan dog ticks, Dermacentor variabilis (Say), and adult tick movement during high host density. J. Entomol. Science. Submitted.

Carroll, J. F. and Schmidtmann, E. T. American dog tick, Dermacentor variabilis (Say), summer activity on equine premises enzootic for Potomac horse fever in South-central Maryland. J. Econ. Entomol. Accepted

Crystal, M. M. Artificial feeding of northern fowl mites, Ornithonyssus sylviarum (Canistrini and Fanzago) (Acari: Macronyssidae) through membranes. J. Parasitol. Submitted.

Crystal, M. M. 1985. Hatching of northern fowl mite eggs held at different temperatures and humidities. J. Parasitology (Res. Note). Vol 71(1):122-124.

Crystal, M. M. Identification of the immature stages and sexes of living northern fowl mites. J. Parasitol. Submitted.

Feldmesser, J., Kochansky, J., Jaffe, H. and Chitwood, D. 1985. Future chemicals for control of nematodes. Proceedings of Agricultural Chemicals of the Future (BARC Symposium No. 8, May 16-19, 1983, James L. Hilton, ed.). Rowman and Allanheld, Pubs. Chapter 25. pp. 327-344.

Hayes, D. K. Automatic monitoring of oxygen utilization in insects. Proc. NATO Chronobiology Engineering Workshop, Cardiff, Wales, April 1985. In press.

Hayes, D. K. 1985. Biological rhythms and development of agricultural chemicals. Proceedings of Agricultural Chemicals of the Future (BARC Symposium No. 8, May 16-19, 1983, James L. Hilton, ed.). Rowman and Allanheld, Pubs. Chapter 28. pp. 365-371.

Hayes, D. K., Halberg, F., Cornelissen, G. and Shankaraiah, K. Frequency response of the face fly, Musca autumnalis (Diptera:Muscidae), to lighting-schedule shifts at varied intervals. Ann. Entomol. Soc. Am. Accepted.

Hayes, D. K. Miller, R. W. and Jaffe, H. Controlled Release Devices. Proc.

NATO Chronobiology Engineering Workshop, Cardiff, Wales, April 1985. In press.

Hayes, D. K., Shade. L., Cornelissen, G., Halberg, E., Miller, R. W., and Halberg, F. Growing role of insects in chronobiologic study: infrared synchronization of Musca autumnalis mortality on shifted lighting regimens by exposure to placebo or ACTH 1-17. Proc. Intl. Workshop on Chronobiological Technologies, Sept 27-28, 1984, Como, Italy. Accepted for publication.

Hayes, D. K., Shade, L., Cornelissen, G., Halberg, E., Miller, R. W., and Halberg, F. Chronomodulatory infradian synchronization by placebo or ACTH 1-17 of Musca autumnalis mortality on shifted lighting regimens. Proc. Intl. Workshop on Neuroimmunomodulation, Nov. 27-30, 1984, Bethesda, Md. In Press

Jaffe, H. 1985 Development of controlled-release systems for insect hormone analogues and their use against arthropod pests of livestock. Proc. 12th Intl. Symp. on Controlled-release of Bioactive Materials, July 1985, Geneva, Switzerland. Accepted.

Jaffe, H., Hayes, D. K. Luthra, R. P., Shukla, P. G., Amarnath, N. and Chaney, N. A. 1985. Controlled-release microcapsules of insect hormone analogues. Proc. 12th Intl. Symp. on Controlled-release of Bioactive Materials, July 1985, Geneva, Switzerland.

Jaffe, H., Wade, C. W. R., Hegyeli, A. F., Rice, R. and Hodge, J. Synthesis and bioevaluation of alkyl 2-cyanoacryloyl glycolates as potential soft tissue adhesives. J. Biomed. Mater. Res. Accepted

Jaffe, H., Wade, C. W. R., Hegyeli, A. F., Rice, R. M. and Hodge, J. Synthesis and bioevaluation of a rapidly biodegradable tissue adhesive: 1,2-isopropylidene glyceryl 2-cyanoacrylate. Accepted.

Miller, R. W., and Miller, J. A. 1985. Feed-through chemicals for insect control in animals. In Agricultural Chemicals of the Future (BARC Symposium 8, J. L. Hilton, ed.) Rowan and Allanheld, Pubs. Chapter 27.

Miller, R. W. and Schmidtmann, E. T. Feeding Cyromazine (Larvadex®) to dairy calves for the control of house flies. J. Agric. Entomol. Accepted.

Morgan, N. O. A method for bioassaying insecticidal residues with field collected female tabanidae. J. Agric. Entomol. Accepted.

Morgan, Neal O. 1985. Blattidae. In: Handbook of Insect Rearing I, (Ray F. Moore, ed.) Elsevier Science Pubs., Amsterdam. pp. 321-328.

Morgan, Neal O., Schmidtmann, E. T., Fons, J. and Hayes, D. K. 1985. 1985. Aircraft Disinsection: An international concern for the protection of man and agriculture. Proceedings XVII International Congress of Entomology, Hamburg, Germany, August 1984. Veterinary Parasitology

Pickens, L. G. and Hayes, D. K. A model which relates captures and populations of face flies to weather in Maryland. Proceedings of the Population Modeling of Arthropods Affecting Animals and Man Workshop, West Lafayette, Indiana, July 1984. Accepted.

Pickens, L. G., Hayes, D. K., Morgan, N. O., Schmidtmann, E. T. and Miller, R. W. Pyramid traps for monitoring Musca vitripennis (Diptera:Muscidae). J. Med. Entomol. In press.

Redfern, R. E. 1985. In Handbook of Naturally Occurring Pesticides, V. 1: Methods, Theory and Practice: Insect Bioassays. Ed. Dr. N. Bhushan Mandava. CRC Press, pp 479-488.

Schmidtmann, E. T. Arthropod pests of dairy cattle. 1985. Chapter 13, Veterinary Entomology, Williams, Broce and Hall, eds. John Wiley and Sons, Inc., N. Y., pp 223-238 (Review).

Schmidtmann, E. T. Face fly, Musca autumnalis De Geer, and aggregation behavior in Holstein cows. Intern. J. of Parasitol. In press.

Schmidtmann, E. T. 1985. Face flies, Musca autumnalis, and ear flap behavior in Holstein cows. J. Agric. Entomol. 2(1):69-72.

Schmidtmann, E. T. and Berkebile, D. R. Relationship between numbers of face flies (Diptera:Muscidae), and nearest-neighbor distance among Holstein cows. Environ. Entomol. Accepted.

Schmidtmann, E. T. and Redfern, R. E. Physiological condition of face flies, Musca autumnalis De Geer, captured from cattle during the fall months. Canadian Entomologist. Accepted.

Schmidtmann, E. T., Russek Cohen, E., Morgan, N. O., Gerrish, R. R., Wilson, D. D. and Gagne, R. J. Survey for exotic Muscoid fly (Diptera:Muscidae). Ann. Entomol. Soc. Am. Accepted.

Schmidtmann, E. T. and Wilson, D.D. 1985. Efficacy of insect suppression treatments, Avian Influenza (AI) eradication task force, Lancaster County, PA, 1983-84. Insecticide and Acaricide Tests Vol. 10, p. 343, #502.

Stokes, J. B., Redfern, R. E., Warthen Jr., J. D., and Jacobson, M. Antifeeding potency of neem formulation. Proc. Beltsville Symposium VIII, Agricultural Chemicals of the future, 1983. (Abstract)

Weber, J. D., Carroll, J. and Hayes, D.K. Synthesis of acetals and esters of propargyl, propenyl and propyl alcohols and the bioassay of these and related compounds as fumigants against Caribbean fruit fly larvae. J. Stored Products Res. Accepted.

STORED PRODUCTS
QUARANTINE USE:

INSECTICIDE AND ACARICIDE TESTS

Common malaria mosquito: Anopheles quadrimaculatus Say
Fall armyworm: Spodoptera frugiperda (J. E. Smith)
German cockroach: Blattella germanica L.
Japanese beetle: Popillia japonica Newmann
House fly: Musca domestica L.
Tsetse fly: Glossina morsitans morsitans Westwood
American dog tick: Dermacentor variabilis (Say)

Neal O. Morgan, USDA, ARS, Beltsville Agricultural Research Center, Livestock Insects Laboratory, Beltsville, MD 20705
Peter C. Witherell and W. Scott Wood, USDA, APHIS, Plant Protection and Quarantine, Hoboken Methods Development Center, Hoboken, N.J. 07030

CANDIDATE PESTICIDE FORMULATIONS FOR QUARANTINE USE, 1984 and 1985: Each year two series of bioassay tests were conducted by exposing laboratory-reared and field-collected insects to insecticidal formulations in transport trailers (ca. 32 m^3 or 74 m^3) at Baltimore, MD, and Miami, FL. Insect species included for one or more series of tests were susceptible (NAIDM) M. domestica, resistant (Gainesville multiple resistant) M. domestica, resistant A. quadrimaculatus, G. morsitans morsitans, B. germanica, P. japonica, S. frugiperda and D. variabilis. The Japanese beetles were field-collected in methyl eugenol-baited traps. Some American dog ticks were field-collected by dragging white flannel cloth over tick-infested fields and all were caged in 30-ml clear plastic portion cups with tops replaced with double layers of tulle, a nylon mesh screen (1 mm^2 openings). Mosquitoes and Japanese beetles were caged in 20-mesh hardware cloth cylinders 20 cm long by 7 cm diam with screened ends. House flies, German cockroaches and fall armyworms were caged in 0.24 liter paper cans with tops replaced by single layers of tulle. Tsetse flies were caged in 55 x 65 x 155 mm boxes made by covering stainless steel wire frames with black tulle. Test species were placed on the floor of each test trailer ca. 10 cm from a side wall near the center and ca. 30 cm from each end. Aerosols were formulated with Freon® 11/12 propellant. Aerosols were released within closed trailers while the applicator walked the length of the trailer. The manually released aerosols were sprayed for the required length of time based on release rate, and accurate doses were obtained by weighing and releasing the materials as necessary to give the required grams of active ingredient for each trailer volume. Dusts were formulated with HiSil® 233 as an inert carrier, premeasured according to trailer volume and introduced into the trailers with a CO_2 pressurized 'gun'. Dusts were administered through an open rear door of each trailer. Following each aerosol or dust treatment the trailer was closed for 10 min, then the rear door was opened, and 20 min later the cages of test insects were removed. Knockdown counts were taken at 30 min and mortality (dead and moribund) counts were taken at 26 h posttreatment. The average air temperature inside the trailer at treatment was 25 ± 6°C.

Based on Log-probit analyses of the data, bendiocarb dust was highly effective against B. germanica as was methomyl dust against P. japonica and S-2703f aerosol against D. variabilis. G. morsitans morsitans, A. quadrimaculatus and NAIDM M. domestica were susceptible to all materials tested against them.

Insecticide and	Test species[a] - LC_{90} (g ai/100m^3)[b]							
formulation	B.g.	D.v.	G.m.m.	P.j.	M.d.N.	M.d.R.	S.f.	A.q.
acephate 30% dust	2.16	<1.37	<1.37	7.72	-	-	-	-
bendiocarb 30% dust	0.98	-	-	-	0.53	1.37	9.27	-
cloethiocarb 30% dust	1.93	2.07	-	>2.07	<1.37	>2.07	-	<1.37
cypermethrin 30% dust	1.47	<2.10	<2.10	2.25	-	-	-	-
FBC 34570 2% aerosol	1.61	<1.40	-	<1.40	0.81	>2.11	2.18	<1.40
FBC 34570 30% dust	1.83	<1.37	-	>2.11	1.40	>2.11	>2.11	<0.14
FMC 54800 30% dust	<1.37	<1.37	-	<1.37	<1.37	<1.37	>1.37	<1.37
LAB 96 114I 30% dust	6.91	-	-	>4.21	>1.37	>2.07	>4.21	1.19
methomyl 30% dust	4.70	<1.37	<1.37	0.88	-	-	-	-
permethrin 2% aerosol	1.83	-	-	>2.11	<1.40	<1.40	<1.40	<1.40
permethrin 25% dust	<2.11	<2.11	<2.11	<2.11				
resmethrin 3% aerosol	<1.37	<1.37	<1.37	>2.11				
d-phenothrin 2% aerosol	1.61	1.30	-	1.97	<1.40	<1.40	<1.40	<1.40
d-phenothrin 30% dust	1.83	2.25	-	3.65	<1.40	<1.40	5.72	<1.40
S-2703f 2% aerosol	1.76	<0.70	-	4.70	-	-	-	-
SLJ 0312 30% dust	>3.51	>3.51	-	>3.51	-	-	-	-

[a]Species abbreviations: B.g. = Blattella germanica; D.v. = Dermacentor variabilis; G.m.m. = Glossina morsitans morsitans; P.j. = Popillia japonica; M.d.N. = Musca domestica susceptible NAIDM; M.d.R. = M. domestica, multiple resistant Gainesville; S.f. = Spodoptera frugiperda; and A.q. = Anopheles quadrimaculatus.

[b]Based on Log-probit analyses.

Aircraft Disinsection: An International Concern[1/] for the Protection of Man and Agriculture

Neal O. Morgan[2/], E. T. Schmidtmann[2/], J. Fons[3/] and D. K. Hayes[2/]

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The advent of the Jet-Age has produced a new concern for agriculture and mankind--the rapid introduction of exotic arthropod pests and/or vectors of diseases as hitch-hikers on international commercial or military aircraft flights. The onetime barriers i.e. deserts, high mountains, and oceans that prevented or greatly reduced introduction of such arthropods, are no longer deterrents to those specimens that can travel undetected when accompanying passengers or in cargo. Foreign animal diseases transmitted by arthropods can no longer be regarded as exotic curiosities of purely academic interest. Now the existence of an arthropod-borne disease in any region may be a threat elsewhere, and within one day can be transplanted anywhere on earth that is serviced by aircraft (Hayes 1984).

Within the past two years an exotic fly, Musca vitripennis Meigen, was introduced into the United States in cargo via jet aircraft arriving from Europe (Wilson, 1982). The fly is common to north Africa, southern Europe, and western Asia and recently has been reported in Sweden. In India Parafilaria bovicola Tubangui, a parasitic nematode of cattle, has been shown to develop to the infective stage in M. vitripennis and causes the cattle disease known as parafilariasis or haemorrhagic filariasis (Sahai and Singh, 1971). The disease is most visible on cattle carcasses that are being prepared for marketing, as infested muscle is discolored like a bruise, the texture is altered, and it must be removed before the carcass is marketable. If that nematode gained entry into North America, in the United States it could be spread by M. autumnalis De Geer, a cattle pest common to most of the country. The subsequent effect on the cattle industry could be devastating through the loss of trimmed meat. Experimental transmission studies carried out in Sweden demonstrated that M. autumnalis obtained from the United States are capable of serving as biological vectors of P. bovicola, as is the European face fly (Wilson, 1982).

In 1970, another exotic Diptera, Hippobosca longipennis Fabricius, entered the U. S. from Africa as an ectoparasite on cheetahs Acinonyx jubatus, destined for zoological parks in five states. During the following two years the alien flies adapted to the new environments, and were appearing on other animals in the neighborhoods. A successful eradication compaign eliminated the pest from the U. S. by 1976 (Keh and Hawthorne, 1977). However, in 1983, a re-introduction of H. longipennis into the U. S. occurred with a shipment of four bat-eared foxes, Otocyon megalotus, from South Africa via jet aircraft. Soon after arrival the animals were observed scratching. The area was fogged with a pyrethrin-base aerosol formulated for fly control. The individual foxes were captured, wormed, and treated with the aerosol to control fleas and lice. During this treatment, one H. longipennis was collected from a fox. Thereafter the fox pen and surrounding animal holding facilities for lions and chimpanzees as well as the animals were treated with carbaryl (Sevin®) or permethrin (Ectiban®) and a brief but effective local H. longipennis eradication program was conducted (Schmidtmann, 1984).

These accidental introductions of exotic ectoparasites into new environments via the rapid transportation of jet travel, and the hasty handling

of sensitive wild animals by not subjecting them to any tiring delays and extra handling en route to new habitats can be controlled. Currently, international laws do not restrict international air transportation of carnivorous zoo animals to those that have been certified as free of ectoparasites. The endangered species are especially protected from undue handling and can harbor many ectoparasites that may remain undetected unless a host dies in transit and must be autopsied. If laws are not approved to protect receiving countries from the introduction of undesirable exotic arthropod ectoparasites from infested countries, the onus should be on the shippers to protect the receiving country. Short of that, perhaps the aircraft cargo transporters should be certain the cargo is arthropod-free. This can be easily accomplished by the "blocks away" method (Sullivan et al, 1962) in which aircraft are sprayed with an aerosol insecticide as the aircraft taxies before take-off. That method of aircraft disinsection was successfully demonstrated over 20 years ago as an effective method for treating passenger carriers without alarming the passengers while exposing any transient insects to lethal doses insecticidal aerosols. Since modern jet aircraft use air circulation systems that provide a complete exhange of filtered air every 3-4 minutes, passengers are only briefly exposed to the treatment. Cargo carriers could use insecticidal dusts for longer insecticidal activity, where it would not be necessary to exchange and filter the air so frequently.

During the first H. longipennis eradication, in California the carbaryl dust was applied to multi-hectare pens containing several cheetahs. People with backpack, motorpowered spray/dusters were able to walk through the pens to within 3-4 meters of the cheetahs, blow clouds of insecticidal dust directly at them, and the animals showed little reaction to the intrusion. Therefore, after the crating and loading of the caged animals into an aircraft and the cargo doors have been closed, the space containing the animals could be disinsected without adding substantially to the discomfort of the caged passengers.

The disinsection of all ectoparasites may not be possible as many species have not been tested for resistance or susceptibility to the insecticides currently approved for use in aircraft. One function of the Livestock Insects Laboratory, Beltsville, Maryland, USA is to evaluate new insecticides as aerosols and dusts against a variety of insects. Among the insects used are resistant and susceptible strains of M. domestica, M. autumnalis, Blattella germanica Linnaeus, Anthonomus grandis Boheman, Spodoptera frugiperda (J.E. Smith), Anopheles quadrimaculatus Say, Heliothus virescens (Fabricius), Rhipicephalus sanguineus (Latreille), Dermacentor variabilis (Say), and Glossina morsitans (Westwood). Although standard methods for evaluating new insecticides or formulations against those species involve exposing caged specimens to ultra low volume ULV treatments in a wind tunnel (Morgan and Retzer, 1981) and field applications in simulated aircraft (65 to 100 cubic meter cargo containers and trailers), most species have been tested in aircraft by the "blocks away" method. By that method caged insects are placed in the overhead luggage compartment, on, and beneath seats in the passenger compartments while the aircraft is parked. Cages of control specimens are sealed in a plastic bag and placed in the galley for the duration of a "blocks away" test. As soon as the aircraft is secured and ready to taxi into a take off attidude, a cabin attendant walks the length of the passenger compartment while releasing a premeasured dose of insecticide from an aerosol can. Usually the treatment goes unnoticed as the passengers are more concerned with seat belts and the people about them. Only after an unusual smelling formulation has been sprayed about the passengers have they commented of the treatment.

During the past five years of wind tunnel and subsequent field trials in

simulated aircraft, several new insecticides have shown promise for aircraft disinsection. Permethrin®, Cypermethrin®, Fenpropathrin®, Fenvalerate® and Baythroid® have given greater than 90% kill to all test species when applied as aerosols and/or dusts at the rate of 1.4g active ingredient/100m^3. All five materials have been formulated for marketing as control agents for other insect/commodity groups. For aircraft disinsection trials the materials are prepared as 2-3% aerosols and/or 30% dusts and the application rates are adjusted by using preweighted dust samples and weighing aerosol cans before and after application to obtain the required dosage. Residues of those insecticides as collected on wood and carpet squares placed on the floors of simulated aircraft for trials have given 100% control of Popillia japonica Newman over two weeks post-treatment. In some ways P. japonica is a highly formidable but seasonal adversary for attempts at aircraft disinsection. The beetle has little if any concern for people or zoo animals. However, hordes of them are attracted to cargo carriers at selected airports, especially of the eastern U.S. They are active during late June and July and will fly over extensive paved areas attracted to the over-sized cargo carrying jet aircraft. Thousands of beetles have been observed on and in jet-powered cargo carriers, especially when cargo doors are open. On transcontinental flights the aircraft cruises above 35,000 ft. where the air temperature is subfreezing. Although the cargo holds have been disinsected, the beetles survive the flights somewhere on the aircraft. Wheelwells and non-cargo holding spaces are considered as beetle hideaways and methods for disinsecting them are being studied.

Currently, only Sumithrin® (d-phenothrin) has been accepted for aircraft disinsection. Not all countries and airlines encourage the practice of aircraft disinsection.

In 1976, some 360 zoos, wild animal parks, animal exhibitors, and animal importers were questioned to survey the introduction, and distribution of H. longipennis within the U.S., and to elicit reactions to the problem of the introduction of an undesirable alien species of Diptera to their facilities. In summary, 18 exhibitors had received carnivores from Africa since 1970. The concern for alien ectoparasites being introduced on new carnivores arriving from another continent was unanimous, but the treatment of import arrivals ranged from doing nothing until a problem appeared to isolation for several months while animals receive complete physical examinations and have adapted to the new surroundings and diet. All exhibitors expressed the need for stricter controls at the ports of entry to include a quarantine of all foreign animal imports until they are certified as free of diseases and parasites. Some people requested strict inspection and treatment of animals at the exporting site, retreatment by aircraft disinsection en route, and repeated treatment on arrival at the destination. The authorities at the San Diego Zoo, San Diego, California, remove and burn all bedding from the shipping crates which are then cleaned and dusted with an appropriate insecticide.

Aircraft disinsection is another means for interrupting the dissemination of pathogens carried by arthropods from areas where the diseases are endemic to disease-free areas. In 1974, Miller, Downing and Morgan demonstrated the ability of Stomoxys calcitrans (Linnaeus) and M. domestica to harbor hog cholera virus for at least 72 hours. M. autumnalis harbored large quantities of the virus through 168 hours. Those data indicate that such common species can become vectors of hog cholera and could be important means for translocating the disease when the conditions are favorable. Flies are commonly found on transcontinental or transoceanic passenger flights.

The potential vectors of economic agricultural diseases and animal ectoparasites may travel, unrestricted, between infested and disease-free areas.

Countries may refuse acceptance of livestock that have not been certified as disease-free, domestic and wild ungulates are quarantined at the ports of entry to the U. S., but there are no international laws that protect importing countries from invasions by ectoparasites on carnivores nor free-flying hitchhiking insect vectors of animal diseases that may arrive from disease endemic areas. It may be difficult to enforce aircraft disinsection for passenger aircraft flying between disease-free areas, to promote an international awareness of potential arthropod disease dispersal by common species, i.e. M. domestica, or to establish a single method for aircraft disinsection that would be acceptable by all companies. Yet, the need for international acceptance of the principles and usage of aircraft disinsection, especially by countries where diseases and ectoparasites of economic importance to man and agriculture are prevalent, is apparent. Shippers should be concerned with the quality and condition of the product shipped. Buyers should refuse infested and/or infected products. Aircraft disinsection at the point of origin could be an inexpensive method for preventing the need for an expensive pest eradication by the receiving country.

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Footnotes

1/ This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended.

2/ Livestock Insects Laboratory, AEQI, Agricultural Research Service, USDA, Beltsville, Maryland 20705

3/ Hoboken Methods Development Center, PPQ, Animal and Plant Health Inspection Service, USDA, Hoboken, New Jersey 07030

FOREIGN TRIP REPORT
for Agricultural Research Service

1. Travelers, title, laboratory, center or field affiliation, location and and NRP:

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2. Country or countries visited and period of travel:

Geneva Switzerland
November 18-24, 1984

3. Purpose of trip:

To attend an Informal Consultation convened by the World Health Organization (WHO) on "Disinsection of vessels and Aircraft", one purpose of which was to revise recommendations for disinsecting of aircraft. At present these recommendations are contained in Annex VI of the International Health Regulations (1969) second annotated edition 1974, and additional recommendations on d-phenothrin are contained in the Wkly. Epid. Rec. No. 21 p. 182 (27 May 1977) and Wkly Epid. Rec. No. 49 p. 382 (7 Dec. 1979).

4. Abstract:

Eleven temporary advisors from 10 countries, one representative of the International Civil Aviation Organization and 10 representatives of the World Health Organization participated in the informal consultation. The recommendations made by the group concerning aircraft disinsection are as follows:

(1) Maintain the recommendations on the procedure for "blocks away" spraying.

(2) Maintain the recommendation on the procedure for on the ground disinsection.

(3) Add a recommendation for residual disinsection using a 2% permethrin spray.

(4) Add a permethrin aerosol (2% in propellents (Freons) 11 and 12 in 1:1 ratio) to the insecticides recommended for use in aircraft disinsection.

The recommendations will be presented to the next appropriate general session of the WHO for approval.

5. Background:

Worldwide aircraft disinsection has not been carried out consistently, and when conducted, the procedures often have been incompletely followed. This consultation was called in order to examine the problem of transport of arthropod vectors of human disease and of rodents in aircraft, vessels and land vehicles. A background agenda and annotated agenda are attached (Encl. 1).

6. Personnel Contacted:

A list of participants is attached (Encl. 2).

7. Activities of the Consultation:

Dr. Hayes prepared an overview of aircraft disinsection and a revision of the recommendations referred to under the above abstract (4). She presented the material, led the initial discussion and the writing group which edited the recommendations, and prepared a new version which she presented to the consultation. The edited recommendations were approved as summarized under the above abstract (4).

8. Results:

A draft report, "Report of a WHO Informal Consultation on Disinsecting of Vessels and Aircraft" including as an appendix the revision of recommendations for aircraft disinsection, was prepared for approval by the World Health Organization. Although the final edited version is not available, the draft that was prepared by the participants is attached (Encl. 3). A working paper by P. S. Dale on "Residual Formulations for Aircraft Disinsection" is also attached (Encl. 4).

9. Recommendations:

The draft recommendations for aircraft disinsection are summarized in the abstract of this report and are detailed in the draft recommendations attached to the draft report, "Report of a WHO Informal Consultation on Disinsecting of Vessels and Aircraft" (Encl. 3).

A large number of working papers were provided to participants by the WHO and copies of these can be made available by requesting them from Dr. Hayes.

RECOMMENDATIONS ON THE DISINSECTING OF AIRCRAFT

RECOMMANDATIONS POUR LA DÉSINSECTISATION DES AÉRONEFS

Reprinted from WHO *Wkly Epidem. Rec.*, No. 7, 1985, pp. 45-47. Tiré à part du *Relevé épidém. hebd.* de l'OMS, N° 7, 1985, pp. 45-47.

RECOMMENDATIONS ON THE DISINSECTING OF AIRCRAFT[1]

Based on the seventh, eleventh and twentieth reports of the WHO Expert Committee on Insecticides and the ninth report of the WHO Expert Committee on Vector Biology and Control

Specifications for aerosols[2]

(a) Aerosols should conform to the required standards.

(b) The insecticidal formulation and its dispenser should be regarded as a single unit required to produce the aerosol.

(c) Net weight and composition of the formulation, the discharge rate and the date of manufacture must be indicated on each container.

General: The dispensers may be either a single-use or a multi-use non-refillable type having a capacity not exceeding 490 cm^3, with the valve protected against accidental discharge. They must comply with the regulations of government(s) and of the International Civil Aviation Organization (ICAO) relating to the transport of dangerous goods by air.[3] If a quantity sufficient for several flight sectors is placed on board, the requirements of the ICAO technical instructions for the safe transport of dangerous goods by air are to be followed.[4] The insecticidal formulation must be free from deposit or suspended matter when cooled to −5 °C (23 °F) or to the lowest temperature encountered in the filling operation, whichever is the lower. The aerosol produced must be non-flammable, free from human toxicity risks and non-injurious to materials used in aircraft construction. Crazing of stressed polymethyl methacrylate plastic (Perspex, Plexiglas) and polycarbonate plastic (Lexan) must not occur.[5]

Dispensers: Detailed specifications and test procedures for single- and multi-use aerosol dispensers for the disinsecting of aircraft are given in the WHO publication, *Equipment for Vector Control* (1974 Ed.).[6]

Discharge: The dispenser shall discharge the formulation as an aerosol at the rate of 1.0 ± 0.2 g per second. The aerosol produced shall comply with the following physical requirements when tested by the WHO test procedures:[5]

[1] These recommendations previously appeared as an Annex to the International Health Regulations. They were not included in the latest edition as it was necessary to review them in the light of technical developments.

[2] See eleventh report of the Expert Committee on Insecticides, section 2.3, Specifications for Aerosols (*WHO Technical Report Series*, No. 206, 1961, p. 10).

[3] Annex 18 to the Convention on International Civil Aviation entitled *The Safe Transport of Dangerous Goods by Air*.

[4] *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (ICAO unpublished document 9284 - AN/905).

[5] See eleventh report of the Expert Committee on Insecticides, Annex 3, Test Procedures for Aerosol Dispensers (*WHO Technical Report Series*, No. 206, 1961, p. 22).

[6] WHO/EQP/6; WHO/EQP/7; WHO/EQP/8.

RECOMMANDATIONS POUR LA DÉSINSECTISATION DES AÉRONEFS[1]

fondées sur les septième, onzième et vingtième rapports du Comité OMS d'experts des Insecticides, et sur le neuvième rapport du Comité OMS d'experts de la Biologie et de la Lutte antivectorielle

Normes pour les aérosols[2]

a) Les aérosols doivent satisfaire aux normes formulées.

b) La production d'un aérosol fait intervenir 2 éléments qu'il faut considérer comme un ensemble: la préparation insecticide et le diffuseur.

c) Le poids net et la composition de la préparation, le débit et la date de fabrication doivent être indiqués sur chaque emballage.

Normes générales: Les diffuseurs devront être d'un type non rechargeable, à utiliser en une ou plusieurs fois, d'une capacité maximum de 490 cm^3 et munis d'une soupape protégée contre tout risque d'ouverture accidentelle. Ils devront satisfaire aux dispositions des règlements nationaux et de l'Organisation de l'Aviation civile internationale (OACI) concernant le transport aérien d'articles dangereux.[3] S'il en est placé à bord une quantité suffisante pour plusieurs sections de vol, il faudra appliquer les instructions techniques de l'OACI relatives à la sécurité du transport aérien d'articles dangereux.[4] Refroidie à −5 °C, la préparation insecticide devra rester exempte de dépôt ou de matière solide en suspension. Il est indispensable que l'aérosol émis soit ininflammable, qu'il ne présente aucun risque de toxicité pour l'homme et qu'il ne soit pas nocif pour les matériaux de construction des aéronefs. Aucun craquelage de la matière plastique à base de méthacrylate de méthyle polymérisé (Perspex, Plexiglas) et de polycarbonate (Lexan) ne devra se produire.[5]

Diffuseurs: La publication de l'OMS intitulée *Matériel de lutte contre les vecteurs* (éd. 1974)[6] donne des normes et des méthodes d'épreuve détaillées applicables aux diffuseurs d'aérosols à utiliser en une ou plusieurs fois pour la désinsectisation des aéronefs.

Débit: Le diffuseur émettra la préparation insecticide sous forme d'aérosol à raison d'environ 1,0 g ± 0,2 g par seconde. Soumis aux essais prévus par l'OMS,[5] le diffuseur devra produire un aérosol satisfaisant aux normes physiques suivantes:

[1] Ces recommandations étaient autrefois publiées en annexe au Règlement sanitaire international. Elles ne figuraient pas dans la dernière édition, car il était nécessaire de les revoir à la lumière des réalisations techniques récentes.

[2] Voir onzième rapport du Comité d'experts des Insecticides, section 2.3, Normes pour les aérosols (*OMS, Série de Rapports techniques*, N° 206, 1961, p. 11).

[3] Annexe 18 de la convention de l'aviation civile internationale sur la sécurité des transports aériens de marchandises dangereuses.

[4] Instructions techniques pour la sécurité des transports aériens de marchandises dangereuses (document non publié de l'OACI 9284 - AN/905).

[5] Voir onzième rapport du Comité d'Experts des Insecticides, annexe 3, Méthodes d'épreuve pour aérosols et pour diffuseurs d'aérosols (*OMS, Série de Rapports techniques*, N° 206, 1961, p. 24).

[6] OMS/EQP/6, OMS/EQP/7, OMS/EQP/8.

(a) Not more than 20% by weight of the aerosol shall consist of droplets of diameter greater than 30 μ.

(b) Not more than 1% by weight of the aerosol shall consist of droplets of diameter greater than 50 μ.

Biological performance: The insecticidal action of an aerosol produced from its dispenser shall not be inferior to that of the standard reference aerosol (SRA) produced from its dispenser when tested by the bioassay method.[1] This bioassay method shall take into account the possibility of resistance developing to the insecticides being used.

Standard reference aerosol

The SRA shall have the following formulation:

	Percentage by weight
Pyrethrum extract (25% pyrethrins)	1.6
DDT technical	3.0
Xylene	7.5
Odourless petroleum distillate	2.9
Dichlorodifluoromethane	42.5
Trichlorofluoromethane	42.5

The net weight of the formulation must be indicated on each container.

Alternative aerosol formulations

Alternative aerosol formulations may be used provided the insecticidal action of a candidate aerosol produced from its dispenser shall not be inferior to that of the standard reference aerosol (SRA) produced from its dispenser when tested by the bioassay method and it fulfills the general requirements above.

The following aerosol formulations have been found biologically effective and safe and have been shown to be acceptable to passengers and crew in the required concentrations:

Resmethrin, bioresmethrin or d-phenothrin without added solvents	2%
Propellant: Freon 11 + Freon 12 (1:1)	98%

The addition of 0.067% petroleum distillate to the d-phenothrin based aerosol has been approved by WHO.

The following compound has also been found biologically effective and safe for use in aircraft disinsection:

Permethrin (25/75 cis:trans ratio)	2%
Propellant: Freon 11 + Freon 12 (1:1)	98%

Disinsecting procedures

1. *Disinsecting before take-off, "blocks away" disinsecting*: This procedure may be followed wherever planes originate from or land en route in areas of risk.

(a) Disinsecting of the passenger cabin and all other accessible interior spaces of the aircraft, except the flight deck, shall be done after the doors have been locked following embarkation and before take-off. Hand-operated aerosol dispensers shall be used. The dispensers shall be serially numbered. The serial number(s) of the dispensers used for the disinsecting of the aircraft shall be entered on the Health Part of the Aircraft General Declaration. Upon arrival at destination, the empty dispenser(s) shall serve, together with the entries on the Health Part of the Aircraft General Declaration, as evidence of disinsecting. All possible sheltering places for insects inside the aircraft shall be treated, including cupboards, chests, toilets and compartments used for clothes, luggage and freight. Foodstuffs and utensils inside the aircraft should be protected from contamination by insecticidal spray.

(b) The flight deck should be treated at a suitable time prior to expected occupancy by the flight crew, the door of this compartment then being closed and kept closed, except when opened momentarily to permit the passage of the crew members, until the "blocks away" treatment and the take-off of the aircraft are completed. The ventilation system must be closed during the spraying and for a period of not less than 5 minutes following spraying.

(c) If it is deemed necessary by an appropriate individual, all parts of the aircraft accessible from the outside only and in

[1] See eleventh report of the Expert Committee on Insecticides, Annex 2, Tentative Method for the Bioassay of Candidate Aerosols for Aircraft Disinsection (*WHO Technical Report Series*, No. 206, 1961, p. 161)

a) 20% p/p au plus de l'aérosol seront constitués par des gouttelettes d'un diamètre supérieur à 30 μ;

b) 1% p/p au plus de l'aérosol sera constitué par des gouttelettes d'un diamètre supérieur à 50 μ.

Efficacité biologique: Evaluée par la méthode d'essai biologique,[1] l'efficacité insecticide de l'aérosol émis par son diffuseur ne sera pas inférieure à celle de l'aérosol standard de référence (ASR) émis par son diffuseur. Cette méthode d'essai biologique tiendra compte de la possibilité de l'apparition d'une résistance aux insecticides utilisés.

Aérosol standard de référence (ASR)

La composition de l'ASR est la suivante:

	Pourcentage p/p
Extrait de pyrèthre (à 25% de pyrèthrines)	1.6
DDT technique	3.0
Xylène	7.5
Distillat de pétrole désodorisé	2.9
Dichlorodifluorométhane	42.5
Trichlorofluorométhane	42.5

Le poids net de la préparation devra être indiqué sur chaque diffuseur.

Autres préparations d'aérosols

On peut utiliser d'autres préparations d'aérosols à condition que l'action insecticide du produit émis par son diffuseur ne soit pas inférieure à celle de l'aérosol standard de référence (ASR) émis par son diffuseur et éprouvé par la méthode d'essai biologique et que le produit réponde aux normes générales indiquées ci-dessus.

Il a été reconnu que les préparations d'aérosols suivantes étaient biologiquement efficaces, ne présentaient pas de danger et étaient acceptables pour les passagers et les membres de l'équipage aux concentrations nécessaires:

Resmétrine, bioresmétrine ou d-phénotrine sans addition de solvants	2%
Gaz vecteur: Fréon 11 + Fréon 12 (1:1)	98%

L'addition de 0.067% de distillat de pétrole à l'aérosol à base de d-phénotrine a été approuvée par l'OMS.

Il a été constaté que le composé suivant pouvait être également utilisé avec efficacité et sans danger pour la désinsectisation des aéronefs:

Perméthrine (rapport cis:trans 25/75)	2%
Gaz vecteur: Fréon 11 + Fréon 12 (1:1)	98%

Procédures de désinsectisation

1. *Désinsectisation avant le décollage: désinsectisation «cales enlevées»*: Cette procédure peut être appliquée chaque fois qu'un avion provient d'une zone à risque ou y fait escale.

a) La désinsectisation de la cabine des passagers et de tous les autres espaces intérieurs accessibles à l'aéronef, à l'exception du poste de pilotage, doit être effectuée après le verrouillage des portes qui suit l'embarquement et avant le décollage. On emploiera des diffuseurs d'aérosols à manœuvre manuelle. Chaque diffuseur portera un numéro d'identification. On inscrira dans la partie relative aux questions sanitaires de la Déclaration générale d'aéronef le ou les numéros du ou des diffuseurs utilisés pour la désinsectisation de l'aéronef. Le ou les diffuseurs vides, lors de l'arrivée à destination, serviront, en corrélation avec les indications portées dans la partie relative aux questions sanitaires de la Déclaration générale d'aéronef, à prouver que la désinsectisation a été effectuée. Tous les emplacements susceptibles d'abriter des insectes à l'intérieur de l'aéronef devront être traités, y compris les placards, les coffres, les toilettes, les vestiaires, les soutes à bagages et à fret. Les denrées alimentaires et les ustensiles de cuisine situés à l'intérieur de l'aéronef seront protégés de toute contamination par l'insecticide diffusé.

b) Le poste de pilotage devra être traité en temps opportun, avant l'heure d'embarquement prévue de l'équipage. La porte sera ensuite fermée et, tant que le traitement «cales enlevées» n'aura pas été effectué et que le décollage ne sera pas terminé, elle sera maintenue fermée, sauf momentanément pour livrer passage aux membres de l'équipage. Le réseau de ventilation devra rester fermé durant la diffusion et pendant une période de 5 minutes au moins après la fin de celle-ci.

c) Si une personne ayant autorité à cet effet le considère nécessaire, toutes les parties de l'aéronef qui ne sont accessibles que de

[1] Voir onzième rapport du Comité d'experts des Insecticides, annexe 2, Méthode provisoire d'essai biologique des aérosols proposés pour la désinsectisation des aéronefs (*OMS, Série de Rapports techniques*, N° 206, 1961, p. 171)

which insects can find shelter, such as cargo holds, are to be disinsected as near as possible to the time the aircraft leaves the apron.

(d) For the disinsecting of aircraft, an aerosol as specified above shall be dispensed uniformly throughout the treated spaces at the rate of 35 g of the formulation per 100 m³ (10 g per 1000 cu.ft.) of enclosed space.

2. *Disinsecting on the ground on arrival*: In cases in which the relevant national authority required on-arrival disinsection, it should be carried out.

(a) All possible sheltering places for insects inside the aircraft shall be sprayed, including cupboards, chests, toilets and compartments for clothes, luggage and freight. Foodstuffs and utensils which may be inside the aircraft should be protected from contamination by the insecticidal spray.

(b) The passenger, crew and freight compartments, the ventilators and all external apertures of the aircraft must be kept tightly closed during the spraying and for a period of not less than 5 minutes following the operation.

(c) For the disinsecting of the interior of the aircraft and any exterior parts which might constitute shelter for insects, an aerosol as specified in the section on biological performance shall be dispensed uniformly through thesé spaces at the rate of 35 g of the formulation per 100 m³ (10 g per 1 000 cu.ft.) of enclosed space.

(d) All parts of the aircraft accessible only from the outside and in which insects can find shelter, are to be disinsected.

3. *Residual treatment of aircraft for disinsecting*: Currently approved aerosol disinsection procedures are not always satisfactory. Permethrin [1] as a residual insecticide has been found safe and effective against important vectors and the method of residual application decreases the risk of adverse effects in those susceptible to inhalation of components of insecticidal aerosols.

This residual treatment should be carried out as follows:

A permethrin (25/75 cis:trans ratio) spray or an aerosol (2% in propellants Freon 11 and 12 (1:1)) may be used for this purpose. The first application should be made so that it results in 0.5 g a.i./m² on carpet and 0.2 g a.i./m² on other surfaces including the cargo and baggage holds. Care should be taken to spray cupboards, closets, toilets and other enclosed compartments where resting insects may occur. Subsequent applications should result in not less than 0.2 g a.i./m² on carpet and 0.1 g a.i./m² on other surfaces.

Each time an aircraft has been treated with residual insecticide, the responsible authority should issue a certificate to that effect. The certificate will remain on the aircraft for presentation to appropriate officials. The responsible official(s) should require that treatment be carried out not less frequently than once a month and at such other times as is necessary to retain the protective insecticide film in an effective condition.

[1] See ninth report of the WHO Expert Committee on Vector Biology and Control (*WHO Technical Report Series*, in press).

l'extérieur et dans lesquelles les insectes peuvent trouver abri, telles que les soutes, devront être désinsectisées au dernier moment avant que l'appareil quitte l'aire de stationnement.

d) Pour désinsectiser l'aéronef, un aérosol conforme aux normes susmentionnées, devra être diffusé uniformément dans tous les espaces traités, à raison de 35 g par 100 m³ (10 g par 1000 pieds cubes) d'espace clos.

2. *Désinsectisation au sol à l'arrivée*: Lorsque l'autorité nationale compétente l'exige, on effectuera la désinsectisation à l'arrivée.

a) Tous les emplacements pouvant abriter des insectes à l'intérieur de l'aéronef, y compris les placards, coffres, toilettes, vestiaires, soutes à bagages et à fret, feront l'objet de pulvérisations. Les denrées alimentaires et les ustensiles de cuisine qui peuvent se trouver à l'intérieur de l'aéronef durant ces opérations devront être protégés de toute contamination par l'insecticide diffusé.

b) Les compartiments réservés aux passagers et à l'équipage, les soutes à fret, les ventilateurs et toutes les ouvertures extérieures de l'aéronef doivent être maintenus hermétiquement fermés, durant les opérations de diffusion et pendant une période de 5 minutes au moins après l'achèvement de celles-ci.

c) Pour la désinsectisation de l'intérieur de l'aéronef et de toutes parties extérieures qui peuvent offrir un abri aux insectes, on se servira d'un aérosol conforme aux normes mentionnées à la section sur l'efficacité biologique, et on le projettera uniformément dans les emplacements indiqués à raison de 35 g de la préparation par 100 m³ (10 g par 1 000 pieds cubes) d'espace clos à traiter.

d) Toutes les parties de l'aéronef qui ne sont accessibles que de l'extérieur et qui peuvent abriter des insectes doivent être désinsectisées.

3. *Désinsectisation des aéronefs par traitement à effet rémanent*: Les procédures de désinsectisation par aérosols actuellement approuvées ne sont pas toujours satisfaisantes. Il a été constaté que la perméthrine [1] est un insecticide à effet rémanent sûr et efficace contre des vecteurs importants, et que l'application d'insecticides à effet rémanent réduit le risque d'effets adverses sur les personnes sensibles à l'inhalation de substances entrant dans la composition des aérosols insecticides.

Le traitement à effet rémanent sera effectué comme suit:

On pourra procéder à une application de perméthrine soit par aspersion (rapport cis:trans 25/75) soit par aérosol (à 2% en utilisant comme gaz vecteurs Fréon 11 et 12 (1:1)). La première application sera faite de manière à répartir 0,5 g m.a./m² de produit sur la moquette et 0,2 g m.a./m² sur les autres surfaces, y compris les soutes à marchandises et à bagages. Il faudra prendre soin de bien appliquer le produit dans les placards, coffres, toilettes et autres compartiments fermés où peuvent demeurer des insectes. Les applications suivantes devraient être d'au moins 0,2 g m.a./m² sur les moquettes et 0,1 g m.a./m² sur les autres surfaces.

Après chaque traitement d'un aéronef par un insecticide à effet rémanent, l'autorité responsable délivrera une attestation. Ce document sera conservé à bord de l'appareil afin d'être présenté aux fonctionnaires compétents. Le (ou les) fonctionnaire(s) responsable(s) devront faire procéder à la désinsectisation au moins une fois par mois ou davantage, si besoin est, de manière à maintenir l'efficacité de la pellicule insecticide protectrice.

[1] Voir neuvième rapport du Comité d'experts de la Biologie et de la Lutte antivectorielle (*OMS. Série de Rapports techniques*, sous presse).

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Synthesis and Bioassay of Acetals and Esters of Propargyl, Propenyl and Propyl Alcohols and the Bioassay of These and Related Compounds as Fumigants Against Caribbean Fruit Fly Larvae

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ABSTRACT

The syntheses of 36 compounds, acetals, ketals, esters and ethers of acetylenic, olefinic and aliphatic alcohols are described. These and 26 related compounds were tested as fumigants against Caribbean fruit fly, Anastrepha suspensa (Loew), larvae. Twenty-five compounds showed fumigant acitvity. 3-Butyne-2-one killed all the larvae exposed to it at the rate 2.2 mg/L for 3 hr, as did the reference fumigant ethylene dibromide (EDB). Six compounds killed 100% of the larvae exposed to them at the rate of 2.2 mg/L for 24-hr. Eight compounds, including propargyl alcohol, propargyl methacrylate and propargyl 3-methylcrotonote, did not kill A. suspensa larvae until a few days after exposure during which interim the larvae apparently grew normally and underwent pre-pupariation wanderlust in synchrony with untreated larvae.

INTRODUCTION

The health hazards imputed to ethylene dibromide (EDB) have prompted regulatory agencies to sharply curtail its widespread use as a fumigant (Anon, 1984) while other fumigants in current use are under scruntiny as posing health risks. As part of a program to detect fumigant activity in more acceptable compounds, we synthesized a series of acetylenic, olefinic and aliphatic acetals, ketals, esters and ethers, and purchased other related compounds for evaluation. Neifert et al. (1925) observed that, as fumigants against grain pests, tertiary alcohols were more toxic than secondary alcohols, which in turn were more toxic than primary alcohols. Benschoter (1977) found that propargyl alcohol had limited effectiveness against Caribbean fruit fly, Anastrepha suspensa (Loew), larvae when used to fumigate infested grapefruit, but we observed 100% mortality of A. suspensa larvae exposed to 10.7%/L for 24 hr on diet medium. We suspected that penetration of the fruit by the fumigant may be the cause of the observed difference. We postulated that systematically substituting the protons of propargyl alcohol with other substituents might result in a compound with better penetration capabilities and/or greater toxicity. Benn et al. (1973) reported esters of tiglic, angelic, ethacrylic and methacrylic acids in the defensive secretion of Carabus taedatus F., so we included a series of unsaturated esters for evaluation. A total of 62 compounds was evaluated as fumigants against A. suspensa .

METHODS AND MATERIALS

Instrumentation - Proton nuclear magnetic resonance (nmr) spectra were determined on a Varian Associates T-60 spectrometer.

Gas chromatographic (gc) analyses were run on a Hewlett-Packard 7620A gas

chromatograph.

Infrared (ir) spectra were determined on a Perkin-Elmer 283 spectrometer.

Syntheses - The acetals and ketals were synthesized by one or more of the methods described (see Table 1 and Table 2).

Method A. Concentrated HCl (0.1 ml) was added dropwise to the vinyl ether (320 m moles) in a 50 ml flask with vigorous stirring. With continued stirring, the alcohol (300 m moles) was slowly added, keeping the temperature below 60°C. After the addition of alcohol was completed, the reaction was monitored by gc (Silar 10C on Chromsorb AW, 0.32 cm ID X 3.6 m stainless steel column, 70°C for 2 min, 30C°/min to 200°). When the reaction was completed or an equilibrium was reached, the mixture was transferred to a separatory funnel and washed with saturated Na_2CO_3. The product was distilled under vacuum. Variations of Method A included increasing the ratio of vinyl ether to alcohol, increasing the acid concentration and using ether as a solvent for solid reactants. Average yield was about 40% and varied from 25 to 75%, based on the alcohol.

Method B. p-Toluene sulfonic acid (12 mmoles, 1.9 g) in ether (10 ml) and the alcohol (300 mmoles) in a pressure-equalizing funnel was slowly added to a vigorously stirred solution of the vinyl ether (600 mmoles) in 25 ml ether. The course of the reaction was followed by gc, as in Method A. The reaction mixture was extracted with "half-saturated" Na_2CO_3 solution (5 ml saturated Na_2CO_3 plus 5 ml water), separated, filtered through cotton and dried over anhydrous Na_2CO_3. The product was purified by evaporating the ether on a rotary evaporator and distilling the crude product under high vaccuum.

Method C. 2-Methoxypropene (16 g) and ether (10 ml) was slowly added from a pressure-equalizing dropping funnel to propargyl alcohol (1.12 g) in ether (20 ml) with vigorous stirring. Analysis by gc (FFAP, 0.32 cm ID x 3 m stainless steel column, 100°C for 2 min then 30°/min to 200°) was used to follow the course of the reaction. The reaction mixture was worked up as in Method B.

Besides the desired mixed ketal, a significant quantity of a second ketal was formed in which the methoxy moiety had been replaced with a propargyloxy group. It was isolated, spectroscopically identified and included in the evaluation for fumigant activity.

Esters. Propargyl and allyl esters of methacrylic, crotonic and 3-methyl-crotonic acids (Table 3) were prepared by the following method. Anhydrous powdered K_2CO_3 (5 g) was suspended by stirring vigorously in ether (10 ml) with dicyclohexano-18-crown-6 (0.5 g). The acid chloride (30 mmoles) was added and then the alcohol (50 m moles) was added dropwise from a pressure-equalizing dropping funnel. After addition was complete, stirring was continued for 2-3 hr. The solution was filtered and the solid was washed with several small portions of ether (about 2 ml each). The combined filtrate and washings was extracted with water to remove excess alcohol. About 2 mg BHT was added to prevent polymerization, the ether evaporated and the product distilled under vacuum. The nmr and ir spectra were consistent with the assigned structures.

Ethyl Propargyl Ether. Allyl ethyl ether was converted to ethyl propargyl ether by bromination and subsequent dehydrobromination by the method of Heilbron et al. (1946).

Bioassay. The methods were described by Carroll et al. (1980, 1982), and a condensed version follows A. suspensa larvae were obtained from a stock colony reared on an artificial diet (Burditt et al. 1975). Two or 3 days after eclosion, larvae to be fumigated were transfered from the stock colony into plastic medicine cups (capacity ca. 25 ml), containing 17±2 g of artificial diet. Five cups, each containing 25 larvae, were used in each test. The next

day, dead, unhealthy, or markedly undersized larvae were removed from each cup and replaced with the same number of healthy larvae of the same age. The open end of each cup was covered with a piece of Masslin Sports Towel held on by a rubber band.

Mason jars (0.95L) served as fumigation chambers with four treatment jars and an untreated control jar per test. A jar was positioned horizontally, and a medicine cup with larvae was placed inside, as from the jar mouth as possible. A disk (5.5 cm in diam) of Whatman glass fiber filter paper was placed in the neck of the jar. The desired amount of test compound was expelled onto the filter paper with a Rainin P20 pipettor, an enameled lid with a latex gasket was quickly and tightly affixed to the jar. The jars and lid were rinsed with methyl alcohol between texts.

All tests were conducted in a fume hood at 20 to 27°C during 24 hr exposures and 24 to 26°C during 3 hr exposures. After exposure, the medicine cups were removed from the jars and "aired out" in the fume hood for 1 to 2 hr. About 8 ml of water was added onto the vermiculite. A paper cap with a hole (ca. 2 mm) in it was affixed to each medicine cup. The insects were maintained undisturbed at 20 to 27°C until 10 to 12 days posttreatment when numbers of puparia were counted. One to 3 days posttreatment untreated and apparently unaffected treated larvae began to crawl from the artificial diet into the vermiculite, where they formed puparia. Mortality was based on the numbers of puparia formed.

Six classes of outcome were defined: Class I = <49% mortality at 10.7 mg/L at 24-hr exposures; class II = 50 to 99% mortality at 10.7 mg/L at 24-h exposures; class III = 100% mortality at 10.7 mg/L at 24-hr exposures; class IV = 100% mortality at 4.3 mg L at 24-hr exposures; class V = 100% mortality at 2.2 mg/L at 24-hr exposures; and class VI = 100% mortality at 2.2 mg/L at 3-hr exposures. If a compound caused 100% mortality at a given protocol (e.g., 10.7 mg/L at 24 hr), it was tested at the next lower dosage (e.g., 4.3 mg/L at 24 hr). The exposure was shortened to 3 hr at 2.2 mg/L, if 100% mortality resulted at 2.2 mg/L at 24 hr. Results were compared to those produced by EDB (1,2-dibromoethane or ethylenedibromide). The classification system was only applied to tests in which control mortality was <16%.

RESULTS AND DISCUSSION

The largest number of derivatives was three mixed acetals each of the eight substituted propargyl alcohols, allyl alcohol and three aliphatic alcohols. Attempts to prepare mixed ketals of these alcohols met only limited success.

The six membered cyclic acetals are used in organic syntheses as a protecting group for alcohols (Miyashita et al. 1977). Of particular importance to this evaluation, acetals are less hydrophilic than the alcohol from which they are made. This should improve vapor penetration of the fumigated medium.

Alcohols 2, 3, 4, 5 (Table 1) each have an asymmetric center and produce diastereomeric mixtures when reacted with suitable vinylethers to produce the mixed acetals which have two asymmetric centers. Diastereomerism was observed by gc and by nmr in each of the 12 cases in which diastereomerism was anticipated, 10-13, 20-23 and 28-31. There were two peaks for the compound in the gc curve of each of these. The nmr spectra had two sets of acetal proton absorption (in the 4.5-5.5 ppm range) in every case in which diastereomerism was expected. Besides the peak doubling due to diastereomerism, peak splitting was observed in the methylene absorption of the ethoxy group in compounds 9-16 and 39-42. This effect in acetals was observed by Bhacca et al. (1962). Jennings (1975) explained this splitting was due to prochirality of the various

conformers of the ethoxy group. This is additional evidence of the correctness of our structural assignments. Avram and Mateescu (1966) list the C-H stretching of terminal acetylenic groups as about 3300 cm^{-1}. All of the compounds we synthesized for which a terminal acetylenic group was expected had the 3300 cm^{-1} band in their infrared spectra. The very weak band at about 2100 cm^{-1} is due to the carbon-carbon stretch of the acetylenic bond and appears in all of the spectra of acetylenic compounds. No special effort was made to so identify purchased compounds. The gc retention times of mixed acetals of the cyclic vinyl ethers dihydrofuran and dihydropyran were all longer than the gc retention time of the starting alcohols. On the other hand, all of the gc retention times of acetals made from ethyl vinyl ether (acetaldehyde acetals) were shorter than the gc retention time of the starting alcohols. Since the reaction worked in only one case, 2-methoxypropene, no generalizations can be drawn about the ketals.

Bioassay. Based on its effectiveness each compound was assigned to one of the six classes described in the methods section. Only compound 60, 3-butyn-2-one, rated in Class VI, with EDB, our reference for effective fumigation. However, the former was the only compound to discolor the artificial diet. Neither compound killed all the larvae at the rate of 1.1 mg/L for 3 hr. Of the remaining 61 compounds tested, 24 rated in Classes II-V (Tables 1-3); three in Class II, eight in Class III, four in Class IV and eight in Class V.

The order of toxicity of the acetals within a group decreased with increased molecular weight. The ethyl propargyl acetals, 9-16, had the same molecular weights as the respective propargyl-oxyfurans, 19-26. Still, the cyclic compounds were as toxic as/or more toxic than the acyclic compound in every case when compared by molecular weight. The esters in Table 3, 49-57, were consistently more toxic than the acetals, but they were also of lower molecular weight.

Most of the Class II-V compounds killed the A. suspensa larvae during the 24-hr exposure, but compounds 1, 9, 17, 18, 19, 27, 56 and 57 resembled some insect growth regulators (IGRs) in their effect on A. suspensa larvae. Control larvae typically fed 3-6 days after confinement in the fumigation jars. They then crawled from the artificial diet up into the layer of milled vermiculite, which had been added to the diet cups 1-3 hr after the exposure period, and formed puparia. Larvae exposed to any of these eight compounds developed synchronously with and similar in appearance to the untreated larvae until they crawled into the vermiculite. Within 24 hr of leaving the diet the fumigated larvae died. Characteristically, the dead larvae were elongate and pitch black; a facies consistent with exposure to these compounds, but not unique. Compounds 17 and 19 rated in Class V. The cause of this effect may have been propargyl alcohol, compound 1. Compounds 56 and 57 can be hydrolyzed to 1, and 9, 17, 18, 19 and 27 can undergo reversed addition to give 1.

Further evaluation of the more effective of these compounds seems warranted. The compounds which produced delayed mortality in the A. suspensa larvae appear to be of interest as possible insect growth regulators.

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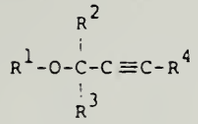
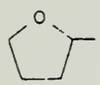
Table 1. Acetylenic alcohol and acetal and ketal derivatives.



Compound	R^1	R^{2a}	R^{3a}	R^4	Method of Synthesis[b]	Bp (mm Hg)	Fumigant Class[c]	Purity
1	H	H	H	H	---	114-115 (760)	V	100%
2	H	H	$-CH_3$	H	---	26 (0.14)	III	99%
3	H	H	$-C_2H_5$	H	---	--- ---	III	---
4	H	H	$-CH(CH_3)_2$	H	---	27 (0.10)	III	100%
5	H	$-CH_3$	$-C_2H_5$	H	---	32 (0.30)	I	100%
6		$-CH_3$	$-CH_3$	$-CH_3$	---	--- ---	I	---
7	H	$-(CH_2)_4-$		H	---	--- ---	I	---
8	H	$-(CH_2)_5-$		H	---	--- ---	I	---
9	$CH_3-CH(O-C_2H_5)-$	H	H	H	A	35-37 (0.45)	V	98%
10	"	H	$-CH_3$	H	A	--- ---	III	98%
11	"	H	$-CH_3$	H	A	33-35 (0.10)	I	98%
12	"	H	$-CH(CH_3)_2$	H	A	30-32 (0.06)	I	98%
13	"	$-CH_3$	$-C_2H_5$	H	A	37 (0.15)	99%	
14	"	$-CH_3$	$-CH_3$	$-CH_3$	A	35 -36 (0.07)	95%	

	R^1	R^{2a}	R^{3a}	R^4	Method of Synthesis[b]	Bp (mm Hg)	Fumigant Class[c]	Purity[d]
15	"	$-(CH_2)_4-$		H	A	42-43 (0.15)	I	91%
16	"	$-(CH_2)_5-$		H	A	--- ---	I	93%
17	$CH_3-O-C(CH_3)_2-$	H	H	H	C	32 (22)	V	85%[e]
18	H-C C-O-C(CH$_3$)$_2$-	H	H	H	C	47 &7)	IV	99%
19		H	H	H	A	37-39 (0.40)	V	98%
20	"	H	$-CH_3$	H	A	30 (0.08)	III	98%
21	"	H	$-C_2H_5$	H	A	41 (0.10)	I	97%
22	"	H	$-CH(CH_3)_2$	H	A	39-41 (0.06)	I	98%
23	"	$-CH_3$	$-C_2H_5$	H	A	65 (0.15)	I	85%

—— Table 1 - continued (2)

	R^1	R^{2a}	R^{3a}	R^4	Method of Synthesis[b]	Bp (mm Hg)	Fumigant Class[c]	Purity[d]
24	"	$-CH_3$	$-CH_3$	$-CH_3$	A	49-49.5 (0.09)	I	87% + 7% unknown
25	"	$-(CH_2)_4-$		H	A	56 (0.07)	I	99%
26	"	$-(CH_2)_5-$		H	A	--- ---	I	93%
27		H	H	H	A	42-48 (0.30)	IV	99%
28	"	H	$-CH_3$	H	A	38 (0.08)	I	98%
29	"	H	$-C_2H_5$	H	A	30 (0.10)	I	95%
30	"	H	$-CH(CH_3)_2$	H	A	65-66 (0.40)	I	98%
31	"	$-CH_3$	$-C_2H_5$	H	A	55-65 (0.15)	I	75%
32	"	$-CH_3$	$-CH_3$	$-CH_3$	A	65 (1.00)	I	98%
33	"	$-(CH_2)_4-$		H	A	60 (0.07)	I	97%
34	"	$-(CH_2)_5-$		H	A	--- ---	I	97%

a. R^2 and R^3 are interchangable; where enantiomers would result, a specific enentiomer is not implied. b. Described in the experimental. c. Described in the text. d. Purity by gc, impurity is the starting alcohol, except where noted. e. Impurity is 18.

Table 2. Aliphatic and Olefinic alcohols and acetal and ketal derivatives.

R^1-OH and R^2-O-CH(-R^3)-O-R^4

	R^1	R^{2a}	R^{3a}	R^4	Method of Synthesis[b]	Bp (mm Hg)	Fumigant Class[c]	Purity[d]
35	$-C_3H_7$	---	---	---	---	--- ---	---	100%
36	$-CH(CH_3)_2$	---	---	---	---	--- ---	---	100%
37	$-CH_2-CH=CH_2$	---	---	---	---	--- ---	II	80% + ethyl ether
38	$-C(CH_3)_3$	---	---	---	---	--- ---	---	100%
39	---	$-C_2H_5$	$-CH_3$	$-C_3H_7$	B	32 (19)	---	59%
40	---	$-C_2H_5$	$-CH_3$	$-CH(CH_3)_2$	B	68-70 (760)	---	50%
41	---	$-C_2H_5$	$-CH_3$	$-CH_2-CH=CH_2$	A	--- ---	II	92%
42	---	$-C_2H_5$	$-CH_3$	$-CH(CH_3)_3$	C	29 (27)	---	90%
43	---	$-(CH_2)_3-$		$-C_3H_7$	B	45 (23)	---	99%
44	---	$-(CH_2)_3-$		$-CH(CH_3)_2$	B	38 (23)	---	99%
45	---	$-(CH_2)_4-$		$-C_3H_7$	B	55-59 (20)	---	100%
46	---	$-(CH_2)_4-$		$-CH(CH_3)_3$	B	50-52	---	99%
47	---	$-(CH_2)_4-$		$-CH_2-CH=CH_2$	A	71-73 (30)	---	100%
48	---	$-(CH_2)_4-$		$-C(CH_3)_3$	B	50-60 (19)	---	90%

a.-d. Same as footnotes in Table 1.

Table 3. Ethers and esters related to the alcohols, acetals and ketals evaluated in this study.

	Compound	Fumigant Class[a]	Method of Synthesis[b]	Purity[c]
49	Allyl formate	V	---	---
50	Allyl acetate	IV	---	---
51	Allyl methacroylate	III	See Text[d]	---
52	Allyl crotonate	III	See Text[d]	---
53	Propargyl formate		--- ---	80% +20% ethanol
54	methyl propiolate	V	---	---
55	Ethyl propiolate	V	---	---
56	Propargyl methacroylate	III	See Text[d]	97%
57	propargyl 3-methylcrotonate	IV	See Text[d]	---
58	Allyl ethyl ether	I	---	---
59	ethyl propargyl ether	II	See Text[e]	90% + 10% glyme
60	3-butyn-2-one	VI	---	---
61	3,4-dihydropyran	I	---	---
62	ethyl vinyl ether	I	---	---

a. See explanation in text. b. Where method not listed, compound was purchased. c. Purity by gc, impurity is starting alcohol except where noted. d. For method of synthesis, see Esters in the experimental. e. Heilbron et al. (1946).